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JUN 28 1922

Volume 8 May, 1922 *Number 5*

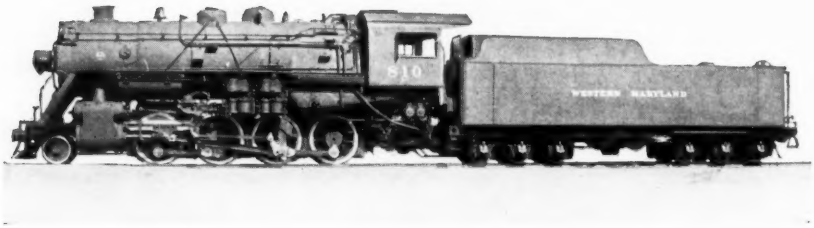
Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

The
Superheated Locomotive
Its Lubrication

PUBLISHED MONTHLY BY
THE TEXAS COMPANY, U.S.A.
TEXACO PETROLEUM PRODUCTS



On the Western Maryland this type of locomotive is known as the H-9 type.

—And lubrication must be good.

A NUMBER of these locomotives have been running for more than a year. They have never been delayed because of lubrication, either on the road or in getting away from the terminals.

The mechanical conditions on this type of locomotive are rather severe:

1 The driving journal loads (per square inch of projected area) **are about the heaviest of any which have come to our attention.**

2 The average temperature of steam at the steam chest (due to the very high superheat developed as operated) **is the highest of which we have any record.**

And therefore the lubrication must be good—especially for cylinders and valves.

Texaco Lubricants are the only lubricants ever used on these locomotives—and despite the severity of the conditions there has been no trouble due to internal or external lubrication. The lubricant which so successfully met the high superheat is our Texaco Superheat Valve Oil.

TEXACO Superheat VALVE OIL

is a carefully refined and accurately compounded oil made especially for the purpose. When used on superheated locomotives it insures better lubrication, greater mileage per pint, long life of packing rings, improved fuel consumption.

This has been the experience not only of the Western Maryland, but on other roads where Texaco Lubricants are proving themselves

THE BEST RAILWAY LUBRICANTS.

Ask Us About:

Texaco Superheat Valve Oil
Texaco Railroad Valve Oil
Texaco Locomotive Engine Oil
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Also anything you desire to know about the complete line of Texaco Equipment Lubricants, Texaco Shop Lubricants, Texaco Illuminating Oils, Texaco Front End Paint, Texaco Crater Compound, and other Texaco specialties for the railroad.

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LUBRICATION

A Technical Publication Devoted to the Selection and Use of Lubricants

Published Monthly by
The Texas Company, 17 Battery Place, New York City
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Vol. VIII — May, 1922 — No. 5

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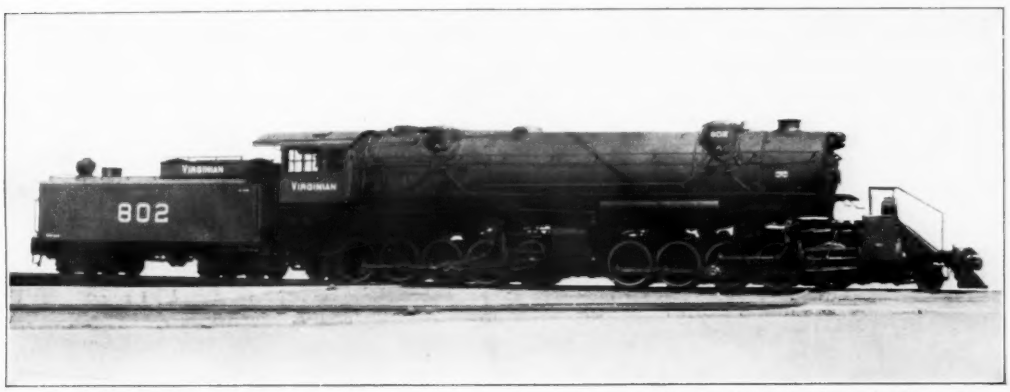


Courtesy of American Locomotive Company.

Fig. 1.—Modern type of Superheated Locomotive used for freight service; total weight of engine 684,000 lbs.; tractive power when operating as compounded engine 147,200 lbs. Driving wheel diameter 56 inches; boiler pressure 215 lbs.; heating surface of superheater 2120 sq. ft.

The Superheated Locomotive Its Lubrication

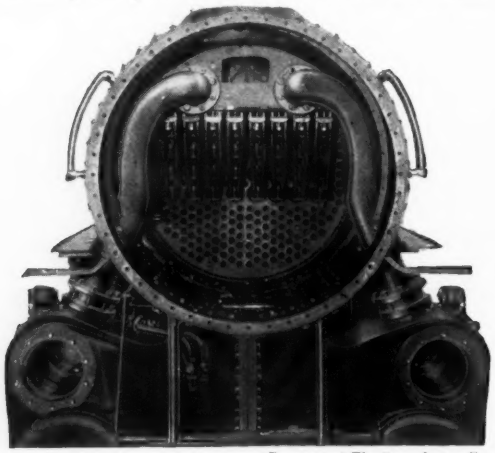
THE operation of a locomotive constructed to use superheated steam involves very close attention to a number of important details, any one of which if neglected may seriously affect the efficiency of the locomotive. Taken in a general way, successful handling means: (1) carrying the water at the proper level to obtain the greatest amount of good out of the superheater; (2) lubricating the engine properly, and (3) handling the engine, while drifting to best advantage in order to take care of the lubricant.

Water Level

The superheater has possibly made some of our enginemen a little careless about the high water level they carry, because of the fact that only in extremely aggravated cases does an excess of water in the boiler manifest itself as positively as it does in engines using saturated steam. There is no condition that is more detrimental to the successful operation of a superheated locomotive than that of carrying the water too high, because it reduces the efficiency of the superheating system by making an auxiliary boiler out of it. This naturally reduces the mean effective pressure at the cylinders, and causes the precipitation of impurities in the feed water to be carried over into the units where they cling to the surfaces and restrict the flow of steam to the cylinders. They are also very likely to be carried in suspension in the

steam in the form of an abrasive into the valve chambers and cylinders, where they make it extremely difficult to lubricate the moving parts.

It is necessary that more care be exercised in handling the water in the modern locomotive than was the case in the past, because the necessary clearance for overhead structures and tunnels restricts the space between the top of the crown sheet and the height of the throttle box in the dome. This condition makes it exceedingly difficult to prevent the syphoning action of the water from the boiler with certain types of throttles, though a properly designed throttle valve may eliminate this syphoning action. The throttle should be so placed in the dome that the least water raises up when the valve is suddenly completely opened. Above all, "solid"



Courtesy of The Superheater Co.

Fig. 2.—Front end View, showing arrangement of Superheater pipes. The *Type "A" Locomotive Superheater*, heating steam to an average of *650° F.*, includes a *top header*, a number of *superheat units*, and an automatic damper arrangement. The special cast iron header is fastened to the tube sheet and joins with the dry pipe in the same manner as the ordinary Tee-head. Two compartments are provided, one for saturated steam, and the other for superheated.

water should be kept out of the superheater equipment. An increase in the height of the water level in the boiler is almost invariably accompanied by a reduction in the degree of superheat indicated at the valve chamber. It is not possible to maintain the same high degree of superheat with the water level unusually high, as it is with the proper amount of water in the boiler, regardless of the condition of the fire. One authority has shown that under actual service conditions, there may exist a difference of 75° superheat, depending on whether the water level is in the third gauge or first gauge and 50° difference in temperature between the third gauge and second gauge. These observations were taken with a pyrometer, and the level of water was watched very carefully. Pyrometer readings in this respect are a valuable aid to both the engineer and the fireman operating superheated locomotives, by clearly demonstrating the unfavorable results from the above irregularities. A specific instance of a mallet type engine when in operation registered normally a pyrometer reading of approximately 625° and when it failed to reach this point a cause could always be found; either the water was too high, the fire not exactly right, the flues or combustion chamber dirty and in one instance it was the means of finding that the superheater damper was not operating properly. The superheater damper, or rather the flag on the weight arm, should certainly be kept in sight of the engineman in order that he can determine from his position in the cab whether or not the damper is working properly.

As regards the proper method of handling the throttle while working steam, a large number of engineers advocate the wide open throttle. It has also been observed that a higher degree of superheat is developed when the reverse lever is worked at a little longer cut off than the trained ear of the experienced engineman would indicate was the proper position. On account of this fact, the highest superheat or steam chest temperature does not result in the lowest water rate.

The development of the higher degrees of superheat often manifests itself by the cracking or peeling off of the paint on the cylinders and the burning of any oil that is present on the outside surfaces of the cylinder casting. This may also be indicated at times by the appearance of the piston rods, which get so hot that they set swabs on fire, although insufficient lubrication or oil of the wrong kind may be more or less responsible for this.

Another phase of this advantage of carrying the water at the proper level is demonstrated in the ability to make a given amount carry an engine over a greater number of miles. This is well expressed by the axiom of an old engineer: "If you want to make water last a long time, keep it out of the boiler and in the tank."

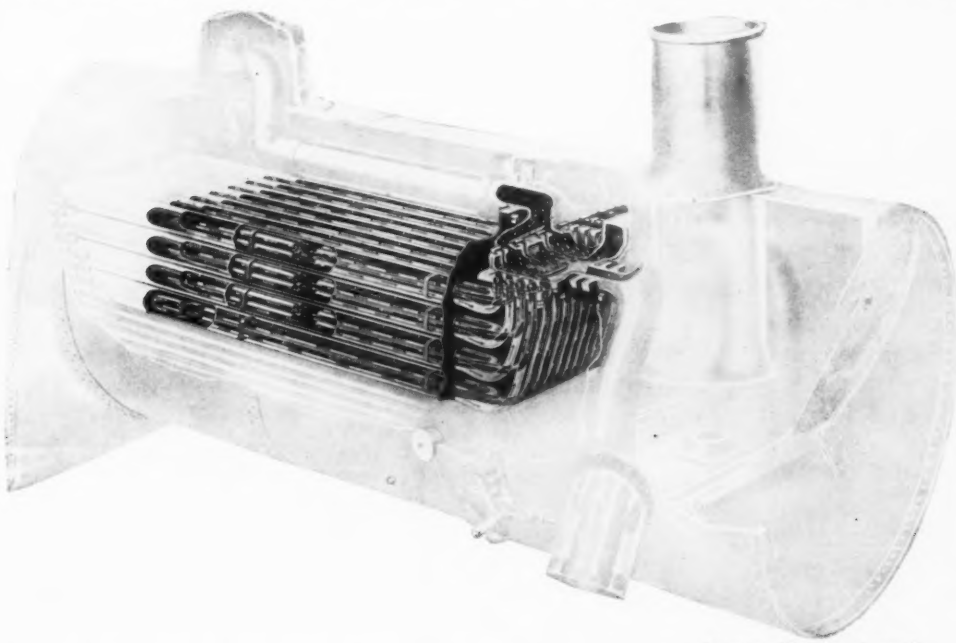
Lubricating Devices

The successful operation of any locomotive depends to a very great extent upon its successful lubrication, which means positive, uniform dependable lubrication with the right kind of lubricant. The extent to which the lubrication will be dependable, positive and uniform is also dependent to a certain degree upon the interest which the engineman and the shop repairman take in the handling of lubricating devices and their care in repairs. There are in use, two methods of lubricating steam locomotives, the forced feed method and hydrostatic method. The tendency in locomotive practice in America has been to adhere to the hydrostatic method of lubrication, although forced feed lubricators are now used more than formerly and a few roads have standardized on forced feed lubricators. The Chicago and Northwestern Railroad has adopted this method as standard and are getting good results. The positive action of the forced feed lubricator, regardless of the steam pressure in the valve chambers and cylinders, the variable rate of feed according to the rate of speed of the engine, feeding faster at higher rates of speed where more oil is needed when reckoned in drops per minute, and the fact that the adjustment of same is not subject to the individual opinion of the engineman operating the locomotive, warrant consideration.

The hydrostatic lubricator on the other hand does have the advantage of being more simple and generally cheaper. There are fewer parts to get out of order and no moving parts to wear out, so that it is still preferred by some engineers.

It cannot be denied that considerable judgment and a certain length of time is required to adjust a hydrostatic lubricator and the engineman is not always disposed to devote time to it. The lubricator should be started a little time before the engine leaves the terminal but in many instances the adjustment of the feeds is about the last thing that is done.

Experience has shown that lubricators may become adjusted so that one side of the locomotive may be getting twice as much oil as the other and in some instances the air pump



Courtesy of The Superheater Co.

Fig. 3.—Phantom of boiler indicating position of superheated pipes. The *Saturated Steam Compartment* has one large opening for the dry pipe connection, and a series of small openings for connections to the intakes of the superheating units; the *Superheated Steam Compartment* has a similar series of small openings for connecting the outlets of the units, and two large openings with bolting flanges are provided for connection to the steam pipes. The *Superheater Units* in which the actual superheating is done, consist of four cold drawn, seamless steel tubes carried as a cluster in the gas area of the large boiler tubes which replace the standard 2" tubes. The four sections of a unit are made into a continuous pipe by *forging* the tube ends into return bands in such a way as to permit a free flow of steam and offer a minimum obstruction to the passage of hot gases through the tubes.

may be getting more oil than anything else, without a reasonable excuse for this action. There is but one correct method of adjusting the feeds on a hydrostatic lubricator and that is by the watch, in "Seconds between drops," or drops per minute. The forced feed lubricators can be adjusted permanently to feed the proper amount of oil per piston stroke, based on calculations of areas of valve and cylinder surfaces. The successful use of the forced feed lubricator in stationary practice in this country, in marine practice and in locomotive practice abroad warrants further study of this method of lubrication.

If the choke fittings on lubricators are not maintained in accordance with the manufacturer's specifications, the feed will be erratic, feeding too fast while the engine is shut off, provided, of course, the lubricator was adjusted while the engine was working steam. The reverse is also true to this extent, that if the lubricator was properly adjusted while the engine was shut off, then the feed will be too slow when the throttle is opened. The valve feeds are quite naturally more affected than are the cylinder feeds for the reason that they operate against a more constant pressure.

The control valve on the modern hydrostatic lubricator is placed there to relieve the engineman of the trouble of having to readjust all of the feeds separately every time the lubricator has to be replenished with oil, to enable him to close all of the feeds (with the exception of the air pump feed) with one operation while standing in side tracks. This is a valuable addition to the modern lubricator. However, control valves are of no value if the enginemen do not use them and it may be said they are not always used in the proper manner. When one takes into consideration the number of regulating valves to adjust on a Mallet type locomotive lubricator, it can readily be realized what it means to adjust each feed separately and correctly.

The general excuse given for failure to use the control valve is that it leaks. If this is the case, then it should be repaired. We also find in some instances at terminal points that employes shut off the steam to the lubricator. This results in a back flow of steam from the tallow pipes, if the throttle is opened, which clouds the glasses and makes it difficult to see the oil as it passes up the sight glass chamber. It is believed best practice not to close the steam valve on the lubricators in case it is necessary to do some work on it or its connections.

If there is not sufficient oil to fill the lubricator to its capacity the amount should be finished out with water, in order to prevent the churning of the oil in the oil well and also to insure the immediate starting of the feeds when the water and control valves are opened.

Courtesy of Locomotive Lubricator Company, and Simmons-Boardman Publishing Co.

Fig. 4.—Mechanical Forced Feed Lubricator. The lubricator lever is operated by a link which is connected to a part of the locomotive valve gear. This operates a ratchet that turns a camshaft in a reservoir containing valve oil. The length of the lubricator lever that controls the amount of oil delivered, is determined by a formula that considers the valve travel, at the normal running cut off, and the diameter and stroke of the pistons.

However, trouble due to the hydrostatic

method of lubrication is not always chargeable to the manner in which they are handled by the engineer, but it is due to the neglect to repair certain parts when engines are undergoing overhauling and failure to maintain certain conditions that are essential to the proper operation of the lubricator.

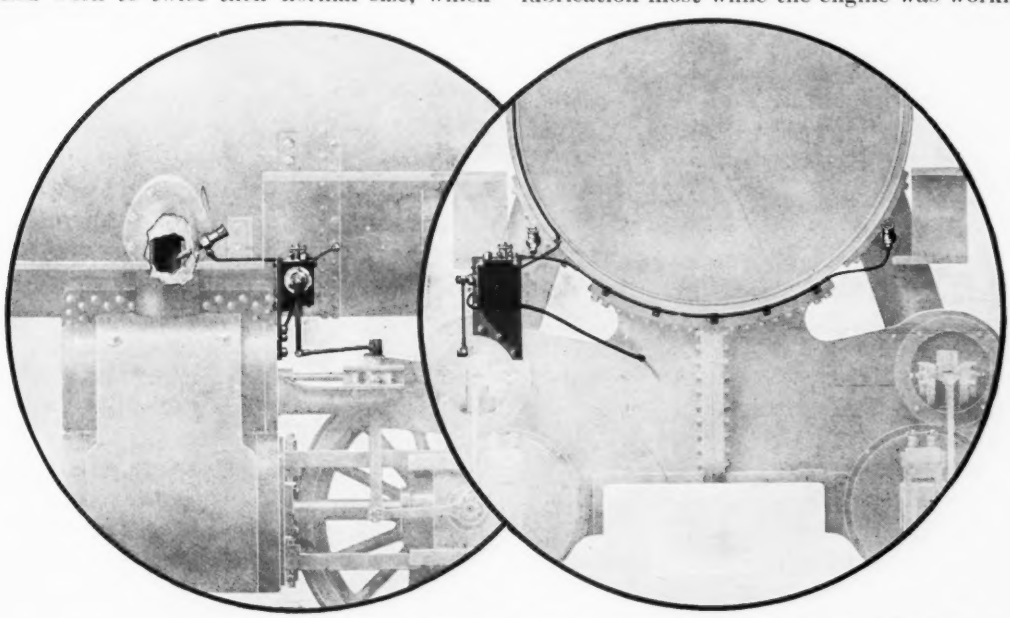
It is often found even when undergoing general repairs that the choke fittings at the steam chests are not removed from the point of application and the dimensions and conditions of them are ignored entirely. If they are badly worn or if the atomizer end is broken off inside the steam passage the successful lubrication of the locomotive is impaired. This more seriously affects the steam chest feeds because of the constant high pressure as compared with that of the cylinder feeds.

Where engines are equipped with steam chest chokes that have the balancing valve in them they are often neglected until the valve has hammered itself into nothing more than a round piece of metal that can have but one effect in drifting, that of shutting off the flow of oil from the lubricator to the valves and cylinders.

In the case of lubricators equipped with the choke fittings at the lubricator, they are often found worn to twice their normal size, which seriously affects the uniform feeding of the oil in the manner previously indicated. This causes the lubricator to feed too fast while the engine is shut off, in case the lubricator was adjusted while there was pressure in the tallow pipes. On the other hand the reverse is also true, that if the lubricator was properly adjusted while the engine was shut off, then the feed will be too slow when the engine is working steam.

Pockets in tallow pipes are certainly objectionable, as oil is unquestionably trapped therein and held for certain periods of time when the engine is working steam. Better results are obtained when these pockets are kept out of the pipes. The tallow pipe should be attached to the steam pipe of the locomotive, a sufficient distance from the steam chest to insure atomization of the oil and the drifting steam connection should, wherever it is possible to do so, be made above the entry of the tallow pipe in order that this steam will aid in the atomization of the oil.

It would, of course, be illogical to advocate the application of the tallow pipe to the live steam passage of a saturated steam locomotive and at the same time condemn pockets in tallow pipes, for the reason that one would affect the lubrication most while the engine was working



Courtesy of Locomotive Lubricator Co. and Simmons-Boardman Publishing Co.

Fig. 5. General arrangement of the Mechanical Lubricator. The oil in the reservoir is kept at pumping temperature by a continuous steam supply through a small pipe against the boiler under the lagging. In this system it is not necessary to place the lubricator in the cab. The oil is delivered at a pressure far in excess of any steam pressure so as to assure of a constant supply.

steam, while the other would affect it most while the engine was drifting. In all instances the oil should have a direct flow by gravity from the lubricator to the point to be lubricated, unless, as has already been stated, some means is provided for atomizing the oil and conveying it in this atomized state to the steam chests and cylinders.

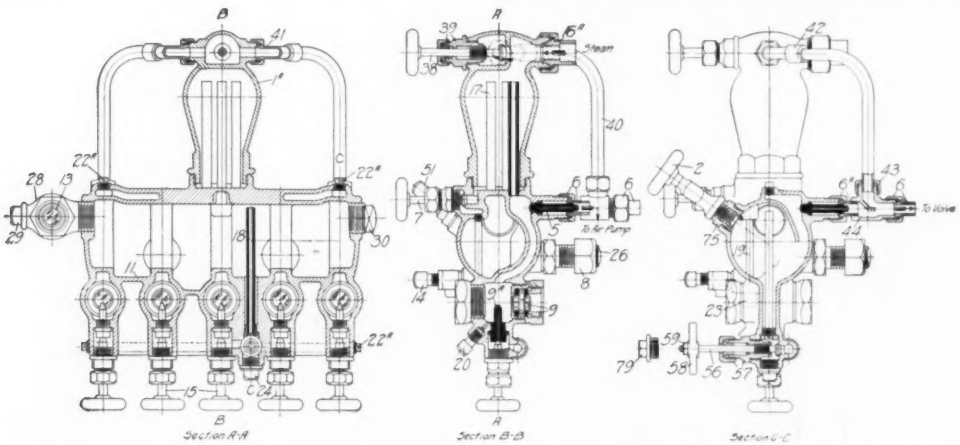
Periodic cleansing of the lubricator to insure that all foreign substance be removed from them is essential to successful operation. We must not lose sight of the fact that carrying water too high in the boiler may also affect the working of the lubricator momentarily and also precipitate solids into its different parts that may clog the feed nozzles, the regulating valves or the choke fittings. There are instances where this foreign matter, mud from the boiler, was so bad that it stopped up the drain pipe completely.

in favor of direct cylinder lubrication may be due to the increase in temperature which retards the collection of atomized oil on the cylinder walls, allowing it to be swept out before it can be of use. No engine can be entirely lubricated through the cylinders without the valve feeds, as the valve admission ring does not receive the proper amount of oil.

Quoting from The Superheater Company:

"As to the point of application of the oil to the locomotive, experience has proven beyond question that the best results will be obtained by feeding oil both to the valves and directly to the cylinders. This has been the recommendation of The Superheater Company, and the railroads that have followed these recommendations are obtaining excellent results, and wear on the piston rings and cylinder bushings is not more than with saturated engines.

"Many railroads have followed the practice of lubricating the engine by feeding and atomizing all of the oil into the steam pipes ahead of the



Courtesy of Nathan Manufacturing Company

Fig. 6—Hydrostatic Lubricator. The hydrostatic lubricator depends for its operation upon the displacement of oil by a body of water which is formed by condensation of the steam in the condensing chamber. (1B) When the water valve (7) connecting the condenser with the body of the valve is opened the condensed water will pass down a pipe (19) to the bottom of the lubricator, and, being heavier than the oil, will stay at the bottom while the oil floats to the top over into the oil pipe (18) which leads to the bottom of the regulating valves (15). The oil is forced up through the regulating valve and through the sight feed glasses (9) from whence it flows into the tallow pipes to the valves and cylinders. The control valve (58) permits the oil supply to be shut off from the regulating valves, except the valve controlling the supply of oil to the air pump, without changing their adjustment. The U. S. Government type of Lubricator is somewhat similar to the above, the principal difference being that the choke fittings (5) instead of being placed at the lubricator, are placed at the delivery ends of the oil pipe except in the case of the oil lines to the air pump.

Point of Feed

As to the point of application of the oil to the locomotive, it has been the general belief until recently that fully 75% of the oil should go to the valves direct. There is a tendency, however, to increase the proportionate amount fed to the cylinders, and one superheater company is beginning to recommend 75% to the cylinders and 25% to the valves. This change

valves, only. This method of lubrication has proven very inefficient for several reasons.

"First: because the finally atomized oil is uniformly distributed throughout the entire volume of steam entering the valves and cylinders, and only the oil held in suspension by the steam closest to the cylinder walls and valve bushings has an opportunity to become deposited and perform its function. The oil suspended by the steam in the center of the cylinder never comes in contact with the wearing surfaces, but is

exhausted and wasted. It is thus seen that lubrication by atomization only, is a very wasteful and inefficient method.

"Another reason is the fact that the water seal which is always present with the use of saturated steam, does not exist with superheated steam, hence the necessity for closely fitted packing rings to effect the same results as the water seal, and thereby avoid a loss of lubrication through blows to the exhaust.

"Where part of the oil is atomized before entering the valve chest, and part of the oil fed directly to the top of the cylinders, the most efficient and effective method of lubrication is obtained. Good results have been obtained by feeding from 50% to 75% of the oil directly to the cylinders, the balance being fed to the atomizer ahead of the steam chest."

There is also some question as to the value of the piston rod swabs and piston rod oil cups. The swab, to a certain extent acts as a wiper and removes the oil from the piston rod, while in the case of oil cups, engine oil with a low flash is generally used. With oil coming from two different sources, and one unsuited for steam cylinder lubrication, it is a difficult matter to determine what is going on inside the cylinder from the appearance of the piston rods. The condition of the piston rod will also indicate generally whether the engine is being properly drifted, because, if it is drifted in such a manner that smoke box gases will enter the valve chambers and cylinders there will be a smutty looking deposit on the rods and the whole appearance of the piston rod will be noticeably dark, the degree depending upon the extent to which the smoke box gases have entered the valve chambers and cylinders.

The shape of the feed nozzle has a direct bearing on the consumption of oil, especially when a change is made from saturated to superheat. A drop of superheat oil will go much further than a drop of saturated oil, due to the difference in the size of the drop. Enginemen as a general proposition, try to make the adjustments for flow at the same rate that they do for saturated oil, with the result that the oil more rapidly feeds away from them until they become better acquainted with it.

Superheat Valve Oil, due to its heavier body feeds a larger drop of oil than does the ordinary valve oil, but this could be reduced in size by changing the shape of the feed nozzles. This is a point that warrants careful study by the lubricator manufacturers as some lubricators feed larger drops than others, even with oil of the same viscosity. If an oil feed can be increased to a greater number of drops per minute for the same quantity, *and still retain its viscosity*, the oil is being fed under more desirable conditions than if it produced a fewer number of large drops.

Oil pipe connections into the steam pipe should, in all cases, be below the point at which steam is taken for the damper superheater cylinder, or through which steam is supplied for drifting. The feed to each cylinder should be located midway between the cylinder heads and as near the top of the cylinder as possible.

Courtesy of The Superheater Company

Fig. 7.—Return Bend Sections. These return bends are made on the ends of the units from the metal of the pipe itself by a special mechanical forging process, without the use of electrical or acetylene welding, and without the addition of any metal or material. The distribution of the metal is such that there is an increase in section at the end. The use of the forged return bend in the unit construction, results in a continuous pipe, the bend being as strong, if not stronger, than the body of the pipe. It also affords an advantageous location of the superheater units.

The lubricator steam pipe connection should be at least as large as recommended by the makers, and the steam taken from a point which will insure full boiler pressure at the lubricator under all conditions.

Selection of Oil

All superheater locomotives in the United States are equipped with superheaters that will deliver a superheat of 250° F. when operating at maximum capacity, and hence only cylinder oil capable of withstanding these temperatures should be used.

The ideal lubricant is a valve oil that has sufficient film strength at high temperatures to prevent the opposing metals from coming in direct contact with one another and at the same time avoid frictional resistance to the movement of the piston.

There is some controversy as to whether superheated or saturated steam conditions exist at the cylinder walls at all times during the stroke of the piston. Some tests seem to prove that there may be saturated steam on the walls

at times, while on the contrary The Superheater Company is positive that under average operating conditions no cylinder condensation exists during operation except possibly during a few revolutions at starting. This claim is based on the fact that under nearly all operating conditions a slight degree of superheated steam exists in the exhaust. In fact the superheaters are designed with the end in view that there shall be no cylinder condensation. Quoting from The Superheater Company:

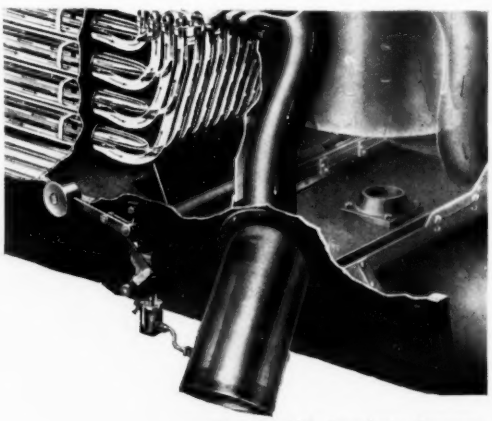
"As the modern superheater locomotive under nearly all operating conditions delivers steam of sufficiently high temperature to entirely eliminate cylinder condensation, it is only during the starting period that a slight amount of cylinder condensation would exist."

Whatever the conditions on the cylinder walls it has been found that a superheated oil compounded with a slight amount of fatty oil, is superior to ordinary cylinder oils. It has also been determined that with a small proportion of fatty oil in the mineral oil, the tendency of fatty oil to form acids is almost non-existent. Therefore, no bad effects would be expected from the use of a slightly compounded oil with superheated steam, and the benefit of the added fatty oil is obtained should saturated steam conditions exist.

Steam cylinder oil must be sufficiently non-volatile to withstand the high temperatures of superheat, especially if fed through the valves. Generally speaking, though not necessarily so, the higher the viscosity the greater the tendency to adhere to the metal surfaces. The average valve oils which may be all right for ordinary conditions, unless especially prepared, break down when the engine is worked unusually hard and develops a degree of superheat that is abnormal. This is noticed to a great extent in piston rod packing failures. Some engineers, when using some of the ordinary valve oils, find it necessary to carry two extra sets of piston rod packing in the seat box to guard against possible failures, and frequently have to apply them on line of road.

Packing

The mean effective pressures in the cylinders and valve chambers, as well as the temperatures, have increased considerably with the introduction of the superheated locomotive. This has, no doubt, contributed materially to the trouble we occasionally have with cylinder packing rings, though this trouble may be partially due to the fact that we are perhaps not as careful as we were formerly in fitting the packing rings into the cylinder. On account of the high velocity and pressure of superheated steam, they should be exactly fitted both as regards the valve and cylinder packing. Fitting rings should be attended with much care, especially as to the diameter as compared with that of the cylinder and valve bushing. There is no question but that more service can be obtained from both valve and cylinder packing if it was more carefully fitted than is usually the case. At the same time a great number of packing rings are removed after comparatively short life, due to the fact that they lose their elasticity (collapse) in a great many instances, before the tool marks are worn off the rings. From a large amount of data it would appear that the ring having the smallest bearing surface against the cylinder walls gives the greatest amount of mileage, provided it is made of the best material.



Courtesy of The Superheater Company

Superheater Damper Arrangement

Fig. 8.—The *damper* is a device for the protection of the superheater units. When the locomotive is working, the steam which passes through the superheater gives ample protection, but when the throttle is closed, no steam passes through the superheater units. In the smoke box, a chamber is constructed completely enclosing the superheater header and the front end of the superheater units to provide complete stoppage of gas flow through the large tubes. The walls of the chamber consist of steel plates which pass down in front of the superheater header and across the smoke box just below the row of large tubes, a section of the horizontal plate being carried on a shaft, to allow it to open or close and form a damper.

A damper cylinder, operated by steam, and a counterweight, are employed to open and close the damper. The counterweight acts directly on the piston of the damper cylinder. One end of the damper cylinder is connected to the steam pipes, so that when the throttle is open, steam enters the cylinder, moves the piston up against the force of the counterweight, and opens the damper. When the steam is shut off, the counterweight closes the damper.

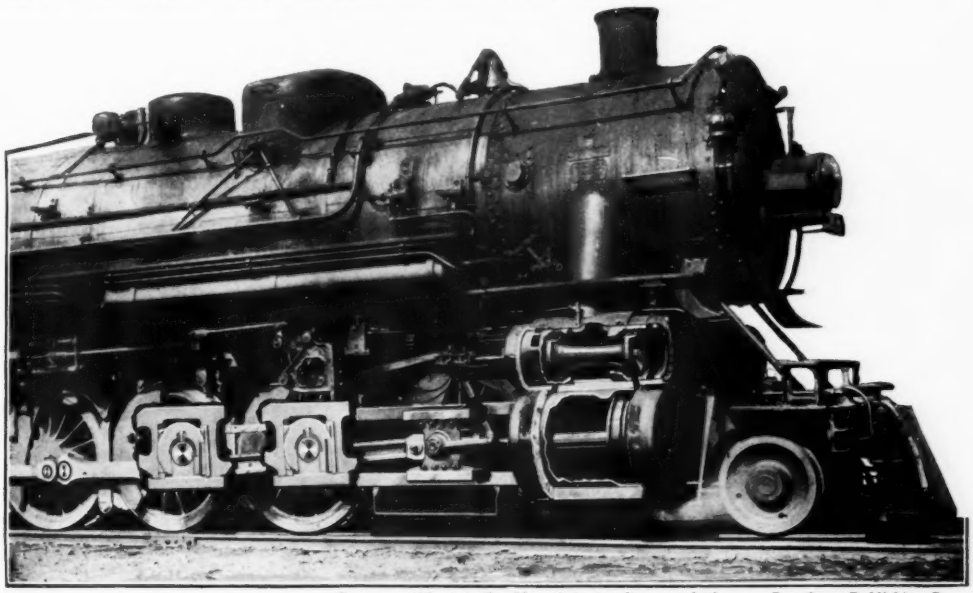
Deposits

Deposits of sticky and solid substances in steam cylinders are strong indications of improper operation. They are usually blamed on the lubricating oil, but analyses show that oil is a very small constituent of them. While a poor or improperly compounded cylinder oil used in large quantities may cause such deposits, usually they consist largely of silica, magnesia, lime and other solids found in boiler water. The small oil content simply holds the solids together. When once a deposit starts it grows easily, as the pasty mass collects readily any dust or dried boiler scale and holds the oil like a sponge so that it is subjected for a long time to the action of the high temperature. By the nature of petroleum, a breaking down will slowly occur.

The point that should be stressed in connection with these deposits is that the engineman does not realize to what extent he is responsible for the formation of the deposits until they have partially restricted the area of the ports, and he will not know, even then, if the mechanical officer does not call his attention to it, whether or not they are caused by high water, improper drifting or too much oil.

If the actual causes for the formations of these deposits could be brought, in a clear, concise manner, before the individual engineers, and they could be made to realize that they are in a measure responsible, it would be only a short while before this condition would be practically unknown.

Material assistance in this respect can be afforded by equipping superheated locomotives with effective drifting facilities, which, if conscientiously operated by the engineer, will share largely in the complete elimination of carbon deposits, and certainly prolong the life of cylinder and valve rings, thereby reducing the cost of maintenance.



Courtesy of Hunt-Spiller Manufacturing Corp., and Simmons-Boardman Publishing Co.

Fig. 9.—A 2-10-2 Superheated Locomotive, showing the interior valve chamber and cylinder with valve and piston in place, also the driving box and frame arrangement.

Amount of Feed

The amount of oil fed to the locomotive certainly has considerable to do with the extent to which these deposits form, as it is the binding agent. At the same time, it should not be reduced to the point where scored valve bushings and cylinders will result. Sometimes an engineer will resort to various sources for securing oil rather than to draw a legitimate amount of excess to replenish his supply, which may have been reduced by some emergency. The result is that he often gets oil from doubtful sources, and of a character entirely unsuited for the lubrication of superheated locomotives.

This condition must have gotten pretty bad in the State of Pennsylvania in 1901, as a law was at that time passed by the legislature, making it unlawful to remove journal box packing or other lubricants from any car or locomotive, the penalty for violation being fixed at "Not less than 500 dollars, and to undergo an imprisonment by separate and solitary confinement at labor, not exceeding five years, or both, or either, at the discretion of the court." The tendency is to treat the induction of smoke gases only in its relation to carbonization, the assumption being that the admission of steam neutralizes the effect of the smoke box gases in its tendency to carbonize the oil. It must be remembered, however, that the admission of steam does not neutralize the cutting action of grit and cinders drawn in with the smoke box gases.

The engineer who lubricates his engine properly with the right kind of lubricant, saves not especially the oil which we have been lead to believe is of first importance, but he saves fuel, cylinder packing and the labor charge for applying same. Have you ever stopped to think what the ratio of lubricating costs to fuel is? A railroad that will use $228,000.00 worth of fuel for a given period of time will pay approximately $3,600.00 for lubricants. If we increase the lubrication cost fifty percent and thereby reduce the fuel bill five percent we will have netted a saving of $9,600.00.

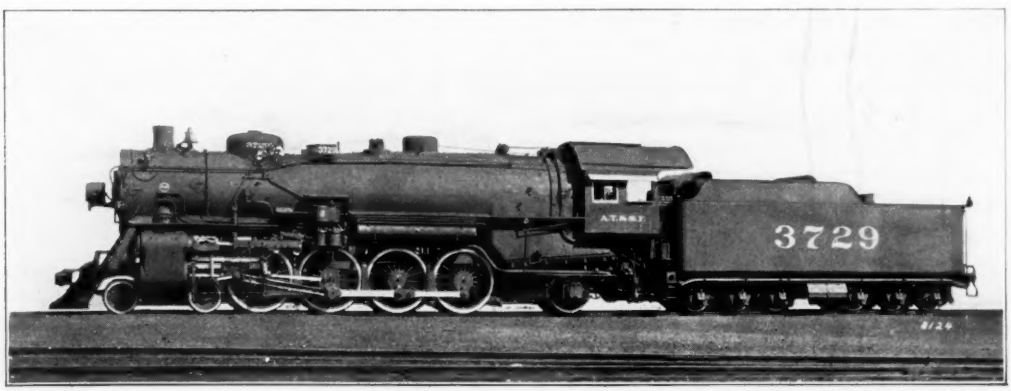
Cylinder packing and fuel cost too much to stint oil at their expense. When we cut the oil down to a point where it is impossible to take care of the engine, the enginemen are going to get the oil somewhere, even if they have to borrow it from a saw mill. There is a correct amount of oil to suit the conditions on each run and this amount should be specified on the oil schedules, regardless of the mileage per pint it indicates.

Drifting

The position of the reverse lever in drifting is often overlooked, or, at least, has not been given the importance which it warrants. Some means of supplying steam to the valves and cylinders in drifting is absolutely necessary, and the position of the reverse lever, or to be more exact, the cut off of the valve, has a direct bearing upon the extent to which this drifting steam gets in its useful work. The position of the reverse lever is controlled, to a certain extent, by the physical strength of the engineer. Let us consider methods of supplying this steam for drifting, and to indicate the best position of the reverse lever, which must accord with the conditions under which the engine is operated. It is not consistent, of course, to advocate drifting an engine on a fast passenger train in full gear, if it is not equipped with a power reverse.

There are three methods in general use in supplying drifting steam:

The main throttle method, the manually operated drifting valve and the automatic drifting valve. It is often necessary to operate engines which have neither relief valves nor drifting valves, it being entirely dependent upon the engineer to use the proper amount of steam, and the engineer who has to do this, with some of the throttles that are in use, is up against a pretty difficult task. There is no question but



Courtesy of The Baldwin Locomotive Works.

Fig. 10.—Mountain Type Superheated Locomotive used for passenger service

that a great deal of coal is being wasted in running locomotives under this method, because, regardless of how careful the engineer may be, he generally gets the throttle too wide open or shut off completely, and in either instance, he wastes fuel, in the former directly, by the use of steam; in the latter case, by destroying the lubricating film in the valve chambers and cylinders, and thereby increasing friction unnecessarily.

In the manually operated drifting valve, the objection has been raised that the engineer is liable to leave the valve open, but this is not a serious objection, as the handling of the valve soon becomes second nature, and an engineer frequently finds himself reaching out for the handle of the drifting valve just before reaching a drifting point, when he is operating a saturated steam engine, after having previously operated a superheated locomotive. If any objection should be offered to this type of valve, it would be that perhaps the engineer *would not* open the drifting valve when necessary, because some of them imagine drifting valves increase acceleration of the train on descending grades and make it difficult to control. This is true only to a limited extent. Manually operated drifting valves are sometimes considered excellent devices to aid in starting a long train where it is necessary that considerable skill be used in order to prevent undue shocks to the rear.

Another point which might be considered favorable to the use of the manually operated drifting valve is its flexibility of action, because it can be opened before the actual closing of the main throttle valve and in a way that will not set up a too rapid change of temperatures in the valves and cylinders, which may affect the valve and cylinder packing.

The most economical method (from a standpoint of steam consumption) of preventing a flow of smoke box gases into the valves and cylinders is that by which the least volume of steam is required to maintain a higher pressure in the cylinders than that which exists in the exhaust passages, whether it be a positive pressure or a vacuum. It might be said at this point that the constant use of the blower in drifting aids materially in preventing induction of smoke box gases from the front end, because it reduces the *absolute* pressure differential between the smoke box and the cylinders. This was noticed by a number of locomotive engineers some time ago who were unable at the time to assign a cause for it.

It is also necessary, in order to get the best results, that the branch pipes from the main supply pipe to drifting valve be equally divided in order to insure a uniform flow of steam to each valve chamber.

With one or two possible exceptions, the automatic drifting valves depend upon the formation of the vacuum in the steam chest to cause them to open. They preclude the possibility of the admission of oxygen from the atmosphere through an open relief valve, and eliminate this possible source of destruction of the lubricating film in the valve chambers and cylinders. Properly designed, where they admit a sufficient amount of steam to do so, they will prevent the admission of smoke box gases from the front end.

It must be remembered that the vacuum that is formed in the steam chest depends entirely upon that which is formed in the cylinders, and is controlled by the position of the reverse lever to a very great extent.

Indicator cards taken of engines while drifting show that the greatest amount of vacuum is formed when the engine is drifted with the valve in full gear (without relief valves.) This is easily explained, because there is no means by which this vacuum can be destroyed, but in the case where the engine is drifted at a shorter cut-off than full gear, the vacuum is unquestionably destroyed by the induction of smoke box gases, which, of course, is undesirable.

Inasmuch as the automatic drifting valve depending on a vacuum to open it, *is dependent* upon this vacuum for its proper functioning, the natural conclusion to be drawn from this is that the proper place to drift the engine is in full gear. This will be done more successfully on engines equipped with power reverse. This position also reduces and equalizes the wear on the valve bushings. With drifting valves, we obtain a very low initial steam chest pressure, and it naturally follows that with this low initial steam chest pressure, if the cut-off is shortened, the steam in the cylinder soon expands to a point where it loses its pressure and a vacuum is formed. However, we must select

the cut-off best adapted to the condition under which the engine is being operated. With the throttle in such condition that it can be operated in only two positions, either wide open or shut off, the logical conclusion to draw from this is that it is impossible to supply the engine with the proper amount of drifting steam, in any position other than a very short cut-off in which the engine is practically "Cut-out." This is, of course, where no other means of supplying drifting steam is provided.

An example can be cited of a Mikado type freight locomotive that had no relief valves, no drifting throttle, and one of those open or shut main throttles. The engineer in trying to drift at a reasonably low cut-off found it difficult to keep the throttle cracked and occasionally unintentionally allowed it to close. This brought about a condition in the cylinders that was immediately noticeable on the piston rods in that they showed a covering of smutty substance that undoubtedly came from the front end. When the method of drifting was changed so that ample steam was admitted to the cylinders at all times, the pistons began to show improvement and the color of the oil on them was restored to its natural shade.

On another occasion, an engine was operated on which there was no power reverse gear, the engine being equipped with relief valves. The engineer had complained that he could not lubricate this engine. We found him drifting his engine in short cut-off and closing his throttle completely at all drifting points. Examination of the pistons on this engine also indicated that smoke box gases were entering the cylinder and the only thing that was done to correct the trouble was to change the method of drifting. It is evident from these two cases, both in which the throttle was not capable of graduated adjustment, that the high initial steam chest pressure compensated to a certain degree for the short cut-off.

In the use of the manually operated drifting valve, the best place for handling the reverse lever is as low as possible consistent with keeping the relief valves closed. Even if the reverse lever is lowered to such a point that a flutter of steam will come out of the relief valves, and then lowered one point lower (to prevent hammering of the valves) no bad effects will result as the amount of steam entering the valve chambers will neutralize the effects of the small amount of air that will enter. In the case of an engine operated in this manner, an examination of the valve and cylinder posts and pistons after it had been in service three years indicated an entire absence of deposits of any nature.

Examples can be given of valve spools where all of the so-called carbon deposits were on the exhaust surfaces of the spool and the surfaces exposed to live steam would be perfectly clean. This condition was observed especially in a number of engines which were operated without relief or drifting valves, depending upon the engineer to crack the throttle. In the case of a mountain type locomotive equipped with an automatic drifting valve and at a time when it was running about fifty miles per hour, the engineer stepped out on the running board and closed the supply valve to the drifting valve and immediately he could smell the oil burning.

In other cases with engines equipped with relief valves, but not equipped with drifting valves, carbon deposits have been found on the steam side of the valve only, indicating that they were probably formed by oxidation of the oil by the admission of air through the relief valves.

Conclusion

The successful lubrication of a superheated locomotive is largely dependent upon the extent of co-operation between the railroad company and the oil company's lubricating engineer. Strictly speaking, it might be said that the duty of the lubricating engineer ends with his recommendation of an oil suitable to the conditions of service, but in practice the lubricating engineer also can advise in regard to conditions that influence the economical and efficient use of his oils and such is the service he personally endeavors to give.

And, after all, the successful operation of a superheated locomotive quite naturally means cooperation between the engine crew, the mechanical department, and their ability to get after the small details. It has been truthfully said that "The habit of analysis, the ability to get under the surface of things and at the vital essentials, gives a man tremendous advantage."

Printed in U. S. A. by
EDGAR C. RUWE CO., INC.
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